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(56) Documents cited  
US 4358692 A      US 3495114 A

(58) Field of search  
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**(54) Stator construction to permit increased heat transfer**

(57) An electric motor is disclosed including heat spikes (36) within the stator slots (34). The heat spike (36) extend radially inward from the stator back iron into the slot (34) between the stator teeth (32). The heat spikes (36) placed within the stator slots reduce the heat path length and increases the heat transfer area to the iron. Together, these allow the winding heat to dissipate quicker and, at the same time, reduce the winding hot spot temperature and improve the motor's load rating.

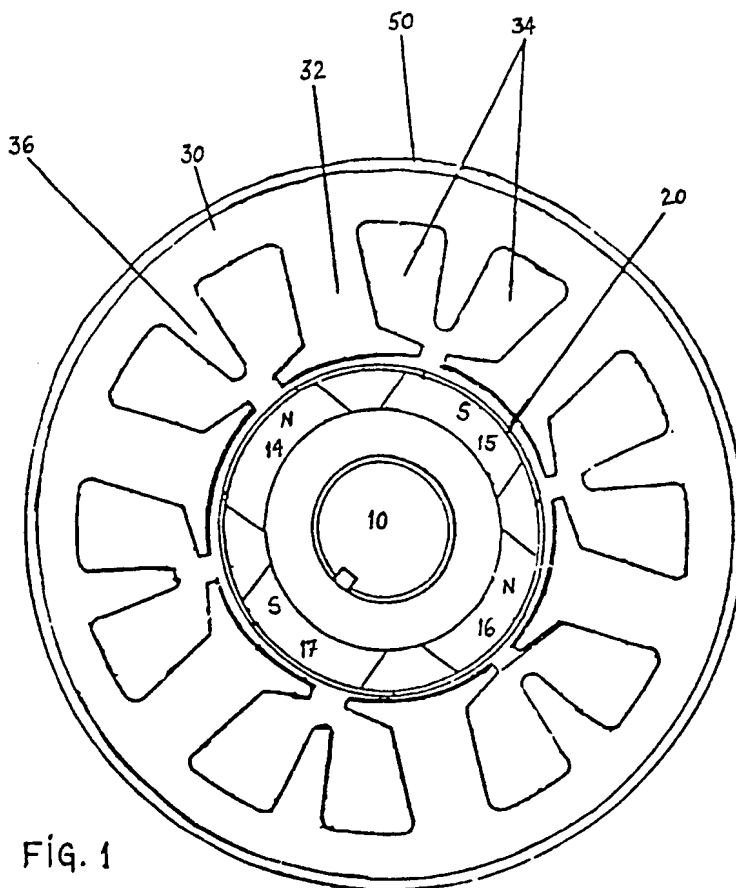


FIG. 1

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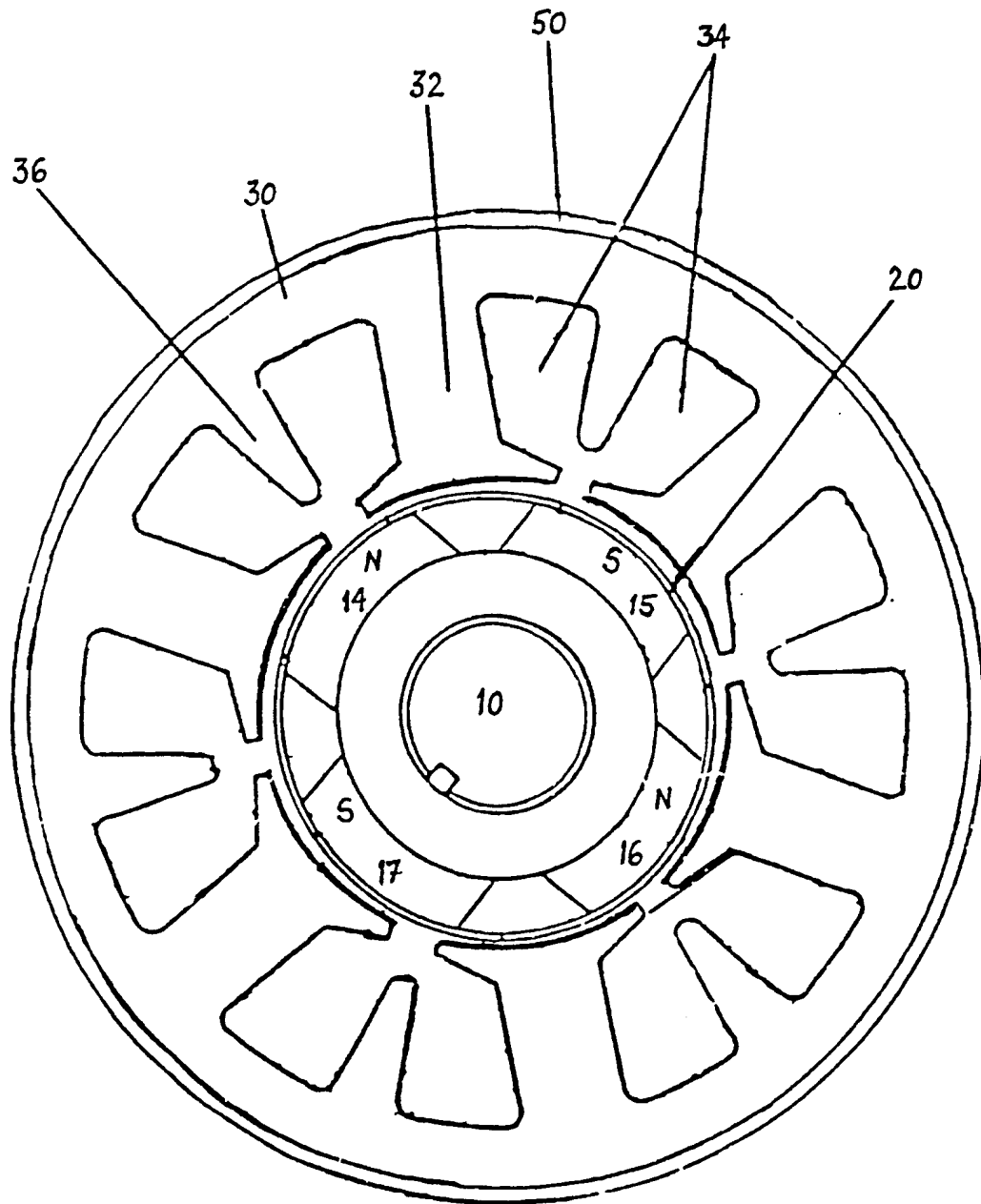


FIG. 1

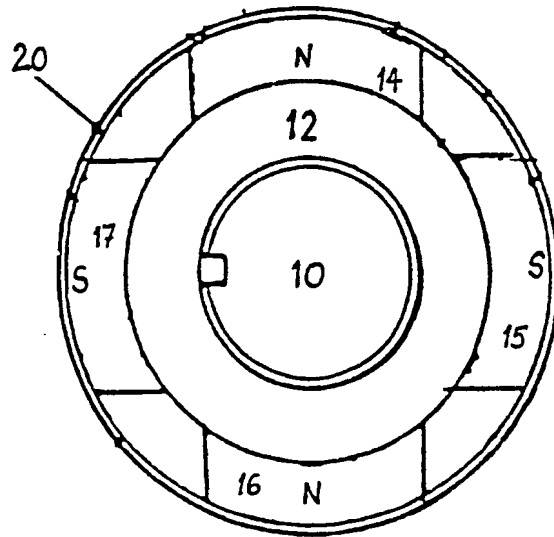


FIG. 2.

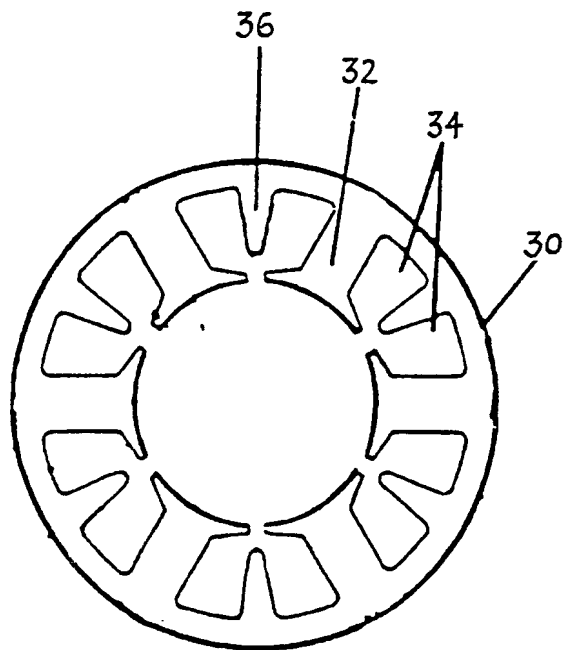


FIG. 3

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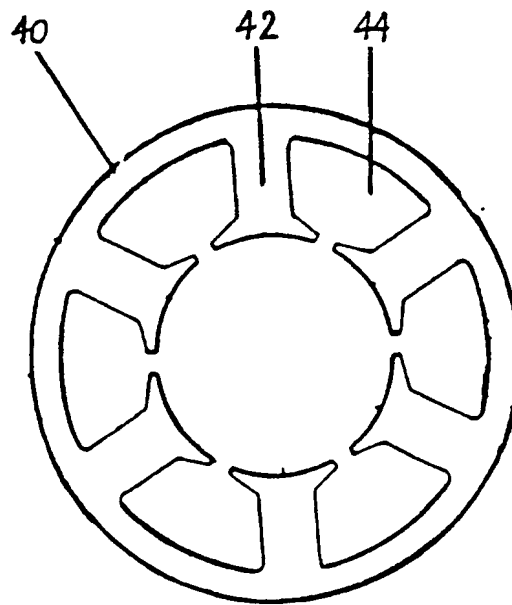


FIG. 4

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MOTOR STATOR HEAT SPIKE

The present invention relates to heat transfer within electric motors. More particularly, the present invention relates to the transfer of heat from the windings to the motor housing.

Electric motor designs often require that the stator have large-  
5 area slots (where the width of the slot is greater than the radial length, or depth, of the slot). A conventional slotted stator without heat spikes is shown in Fig. 4. The stator structure includes a cylindrical outer shell 40 made of laminated silicon steel. This shell provides the outer back iron for the motor. The stator shown has six  
10 teeth 42 and, therefore, it has six slots 44. The six stator teeth 32 are equally spaced around the circumference of the stator shell 40. The stator teeth 42 extend radially inward from the stator shell. Since the stator teeth are equally spaced they define six slots 44 of approximately equal areas. Within the stator slots, electrical conductive wires,  
15 known as stator windings, carry current. These stator windings are not perfect conductors and, therefore, the current travelling through them generates heat within the slots.

The heat generated by the stator windings causes the temperature of the motor's constituent materials to rise. As their temperature  
20 rises, the properties of those materials degrade. For example, the energy product of the magnets used decreases as the temperature increases. Thereby, the generated heat causes a decrease in the motor's continuous load rating. Furthermore, the materials used to insulate the windings can brake down at higher temperatures and the life of the  
25 insulating materials will decrease.

The decreased performance is more pronounced in motors with large-areas slots. The generated heat dissipates along a path from the windings to the lamination iron and motor housing. Thus, the heat generated nearer to the slot's center does not dissipate as easily as  
30 that nearer to its boundary since the heat path is longer. Accordingly, the temperature near the slot center rises above the average temperature of the windings. The greater the distance of the slot center from the slot boundary, that is the larger slot area, the greater this temperature difference (called the hot spot temperature) becomes. This  
35 hot spot temperature limits the motor's continuous load rating because the current in the windings must be limited so that the insulation temperature rating is not exceeded.

Despite the above-mentioned problems, electric motors are still designed with large-area slots for various reasons, including the reduced manufacturing cost due to the small number of stator slots. However, for motors with large-area slots, there is a need to improve the continuous load rating by improving the heat transfer from the stator windings to the motor housing.

It is an object of the invention to improve the heat transfer from the stator windings to the motor housing.

Another object of the invention is to reduce the hot spot temperature in the stator windings.

A further object of this invention is to increase the continuous horsepower rating of an electric motor which contains large-area slots.

In accordance with the instant invention, an electric motor includes a heat spike within the stator slot which extends radially inward from the stator back iron into the slot between the stator teeth. The heat spike, placed within the stator slot, reduces the heat path length and increases the heat transfer areas to the iron. Together, these allow the winding heat to dissipate quicker, thereby reducing the hot spot temperature and improving the motor's load rating.

The following drawings, along with the detailed description, serve to illustrate a preferred embodiment of the invention.

Fig. 1 is a cross-sectional end view of a motor according to the invention.

Fig. 2 is an end view of the rotor portion of the motor.

Fig. 3 is a view of the motor stator lamination with heat spikes in accordance with the invention.

Fig. 4 is a view of a motor stator lamination without heat spikes according to the prior art.

The basic structure of a motor according to the invention is shown in Figs. 1 to 3. Those elements of electric motors well known to those skilled in the art will not be described herein as they do not comprise essential elements of the invention.

An electric motor according to the invention includes a steel shaft 10 surrounded by a cylindrical iron sleeve 12 which provides the back iron for the rotor. Four permanent magnets 14, 15, 16, 17 are mounted on and extend radially outward from the sleeve 12. The mag-

net assembly may be arranged to provide alternating north and south poles as shown in Fig. 1.

To hold the magnets in place under high speed centrifugal force, a banding 20 surrounds the rotor structure. Banding is typically accomplished by first dipping high strength Kevlar filaments in epoxy and then winding these around the rotor. The banding 20 may include one or more helical layers followed by several hoop layers.

Each magnet used can extend the full length of the rotor or, alternatively, they can be segmented. An advantage in using segmented magnets is that a single motor design can provide motors with different horsepower ratings simply by changing the motor length and the number of magnet segments.

In contrast to the conventional stator in Fig. 4, the stator in Fig. 3, in accordance with the instant invention, has a heat spike 36 added into each slot 34 (six in number). Each heat spike 36 is located at the approximate midpoint of the slot 34 arc along the stator shell 30 between teeth 32. The heat spikes 36 are widest at their base because the closer they are to the stator shell 30, the more heat they have to conduct. The heat spikes 36 extend radially into each slot 34 and become narrower at their ends opposite from the stator shell 30. The housing 50 supports the entire motor and dissipates most of the heat to the surrounding medium.

In addition to the heat spikes 36, the stator in Fig. 3 includes other important differences from the conventional stator in Fig. 4. To provide space for the heat spike, a trade off between slot area for the winding and stator teeth area for the magnetic flux must be balanced.

To accommodate the heat spike in the stator slot, either the windings lot areas or the back iron areas must be reduced. While conventional slotted stator designs suggest that reducing these areas would reduce the motor's performance, it has been found that the improved heat transfer from the addition of the heat spikes more than compensates for the reduced winding or stator tooth areas. In fact, instead of reducing motor performance, it is actually improved.

Electric motors built in accordance to the invention have increased horsepower and have shown a reduction in the winding hot spot temperature. In fact, electric motors constructed according to the invention have shown a 7.38% increase in horsepower and a reduction



in the hot spot temperature from 19°C to 2.2°C above the average winding temperature as compared with an electric motor run at the same speed but without stator heat spikes.

Although only one illustrative embodiment of the invention has  
5 been described in detail, there are many variations that come within the scope of the invention.

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## CLAIMS:

1. An electric motor comprising a stationary wound member; a moveable field member, the magnetic field of said moveable field member interacting with the energized windings of said stationary wound member and causing said moveable field member to move relative to said stationary wound member; a plurality of heat spikes (36) of thermally conductive material extending from the stationary wound member adjacent to said windings; and support means for maintaining an air gap between said stationary wound member and said moveable field member.

2. The electric motor of claim 1 wherein said stationary wound member is a stator and said moveable field member is a rotor.

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3. The electric motor of claim 2 wherein said stator includes a plurality of stator slots (34), each stator slot (34) having at least one heat spike (36) of thermally conductive material extending radially inward from the stator into each stator slot (34) and having said windings located therein.

4. An electric motor comprising a stationary wound member; a moveable field member, the magnetic field of said moveable field member interacting with the energized windings of said stationary wound member and causing said moveable field member to move relative to said stationary wound member; a plurality of heat spikes (36) of thermally conductive material extending from the moveable field member adjacent to said windings; and support means for maintaining an air gap between said stationary wound member and said moveable field member.

5. The electric motor of claim 4 wherein said stationary wound member is a stator and said moveable field member is a rotor.

6. The electric motor of claim 5 wherein said rotor includes a plurality of slots, each slot having at least one heat spike (36) of

thermally conductive material extending radially outward from the stator into each rotor slot, and having said windings located therein.

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**Patents Act 1977  
Examiner's report to the Comptroller under  
Section 17 (The Search Report)**

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**Relevant Technical fields**

- (i) UK Cl (Edition K ) H2A (AKC7)
- (ii) Int Cl (Edition 5 ) H02K 1/20 1/32 9/22

**Search Examiner**

J Cockitt

**Databases (see over)**

- (i) UK Patent Office
- (ii)

**Date of Search**

14 December 1990

Documents considered relevant following a search in respect of claims

1-6

Category (see over)	Identity of document and relevant passages		Relevant to claim(s)
X	US 4358692 A	AKTIEBOLOGET See inter winding cooling ridges	claim 1 at least
X	US 3495114 A	KAZANSKY See projections 6 (figure 3)	claim 1 at least

Category	Identity of document and relevant passages	Relevant to claim(s)

#### Categories of documents

X: Document indicating lack of novelty or of inventive step.

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E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

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